

Design of a 500 Ton Bituminous
Coal Washing Plant

H. J. Sawtell

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bituminous coal washing

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DESIGN
OF A
500 TON BITUMINOUS
COAL WASHING PLANT

A THESIS

PRESENTED BY

H. J. Sawtell

TO THE

PRESIDENT AND FACULTY

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DESIGN OF A 500 TON BITUMINOUS COAL WASHING PLANT.

THECIS

BY

HENRY JACOB SAWTELL,

PRESENTED JUNE 1906.

To make the operation of the plant more easily understood, and to show the development reached in this work, a short account of the action of the machines is here given with a short history tracing the development from the crude early machines to those now in use. The descriptions are necessarily brief.

By coal washing is meant the process of separating the impurities with which the coal is mixed as it comes from the mine by means of special machines which use water as an accessory.

The coal as it comes from the mine consists of coal proper, and impurities, such as slate, sulphur in the form of pyrites or calcium, and magnesium sulphate, bone coal, and fire clay. With some exceptions these substances have a higher specific gravity than the pure coal, which is about 1.28 or 1.30, and it is this fact that makes their separation possible.

The principle of the washer is demonstrated when two substances of different specific gravities are shaken together in a box. The heavier substance will settle in a layer on the bottom, while the lighter substance will re-

main in a layer on top. This would not occur in a vacuum; water is a better medium than air.

The method of washing to separate materials of different specific gravities is a very old one. It has been used in mining operations for a long time. In its use with precious metals the process is reversed, it being desired to save the heavier substance and get rid of the lighter.

Almost every conceivable arrangement has been used; the process has been developed from the simple trough washer to the sensitive jigs. Some have tried air as the medium, others use centrifugal force, but none have proved as satisfactory as the jigging method.

The simplest washer is known as a trough washer, and consists of an inclined trough with cross riffles at regular intervals. The coal is fed at the top and is given sufficient force by the water flowing down the trough to carry the coal over the riffles with it, leaving the slate on the recesses. At the bottom is a draining screen which separates the coal from the water. The slate is removed at intervals by an attendant with a rake. This is a very crude and imperfect method, and requires an excessive amount of water.

An improvement on the simple trough washer is the Elliott trough washer. This consists of an inclined trough in which a flight conveyor operates. The coal and impurities are fed at the center of the trough. Water enters at the top. The flights on the conveyor act as the riffles,

the water washing the coal over the flights. The impurities are carried up the trough and are discharged at the top end. The coal passes down the trough to a receiving car, passing over a draining screen before it enters the car. The process is thus continuous and requires but little attention. Its marked simplicity is a feature, but a large quantity of water is required and the work rather expensive because of its imperfect separation.

Another washer along this line is known as the Scaife trough washer. This consists of an inclined semi-circular trough, about two feet in diameter, and twenty-four feet long, provided at intervals with riffles. Running along the center of the trough is a shaft provided with fingers which act as stirrers. The shaft is given a reciprocating motion. The raw coal is fed at the upper end. The impurities remain on the riffles, the washed coal being discharged at the lower end. When the riffles are full the supply of coal is shut off, the good coal remaining in the trough is washed off and the trough cleared by dumping the refuse into a box below. The process is intermittent, but the advantages claimed for it are its simplicity and the lack of a screen to wear out. The fingers or stirrers which are the only parts subject to much wear being easily replaced.

The Campbell bumping table consists of a shallow trough 2 1/2 x 8 ft. x about 6 or 8 inches deep, open at both ends. It is hung in an inclined position, and by

means of a cam is thrown against a bumping post at the upper end. The coal is sluiced on with water and as the bumping table is thrown against the post the impurities are thrown off the upper end while the pure coal is washed off the lower end with the water.

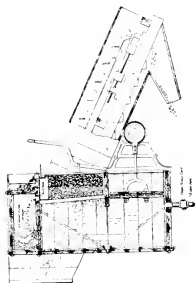
The Robinson washer is of different construction. The coal and refuse are fed at the top of the vessel which is of the shape of an inverted cone. Water enters at the bottom with sufficient force to carry the coal over one side with it. The impurities settle in the bottom. A vertical shaft with stirring fingers attached keep the mass agitated thus allowing a better separation.

An arrangement of German origin drops the raw coal past a blast of air which is of sufficient strength to force the pure coal to one side allowing it to drop into a bin. The impurities drop past into a refuse bin.

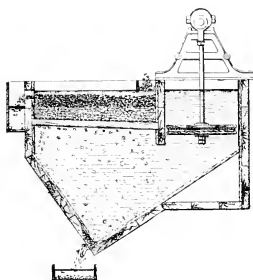
A separation by means of centrifugal force has been used in the anthracite fields. A spiral trough is revolved to throw the slate in the coal, which is fed at the upper end, off the trough allowing the pure coal to slide down into a bin at the bottom. This is merely a rough separation.

Jigs have to a large extent replaced the older methods of washing, being more economical and thorough.

The Luhrig jig is typical and is widely used, giving excellent results with economical working. The two cross-sections here shown are for nut and fine coal treatment. The nut coal jig consists of a box or chamber separated

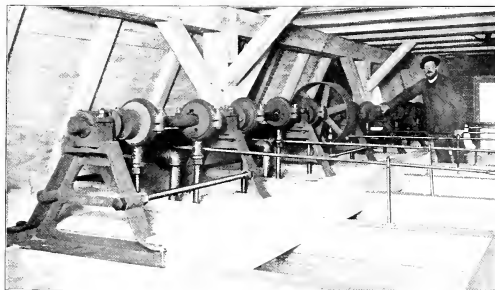


LÜHRIG NUT COAL JIG
 THE LÜHRIG NUT COAL JIG AS ARRANGED "THE OLD"
 MACHINE FOR AUTOMATICALLY
 REMOVING THE REFUSE



LÜHRIG FELDSPAR JIG
 LÜHRIG FELDSPAR JIG AS USED FOR EXCLUSIVE
 FINE COAL. THE USE OF COARSE FELDSPAR
 FOR A BED PERMITS THE USE OF A
 COARSE AND SUBSTANTIAL
 SCREEN

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SHOWING A TYPICAL BATTERY OF LÜHRIG JIGS

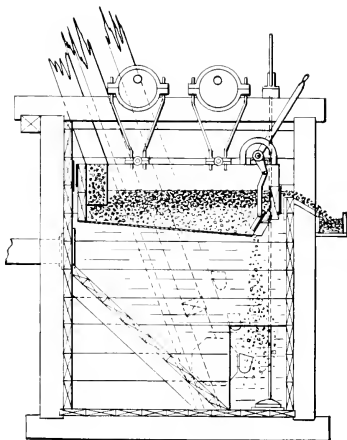
— at about the center by a partition extending about half way down from the top. On one side is a plunger which is actuated by an eccentric through a connecting rod. On the other side is a screen on which the raw coal is fed. The screen is inclined, the coal being fed at the upper end. The plunger imparts a pulsating motion to the water which fills the entire box and this motion agitates the body of coal. The impurities being heavier settle in a layer on the bottom on the screen. The mass gradually works to the lower end where the coal is washed over the sill with the water. The impurities pass through an opening under the sill which is known as the slate valve. Below this slate valve is a conveyor trough into which the impurities fall and are carried by the screw conveyor to an elevator boot. The elevator raises the impurities to a trough or conveyor which leads to the refuse heap. This slate valve opening can be regulated so as to keep a uniform bed of impurities on the screen and thus prevent good coal from passing through the slate valve and being wasted. The coal is sized before being fed to the jig so that very little passes through the screen. Most of the material that does pass through the screen is very fine and is refuse, so a draining valve is placed in the bottom of the box to allow this waste material to be run off. This draining valve is connected to a sluice way which leads to the refuse settling tank. A continuous supply of water is fed at the rear of the jig through the pipe shown.

The fine coal jig is of about the same construction and operation, but differs in the manner of handling the waste materials. In these jigs it is necessary to handle coal from that which will pass through a $\frac{3}{4}$ inch round perforation down to a fine dust. The box is divided as in the previous case with the plunger on one side and screen on the other. On the screen is placed a layer of feldspar which has a specific gravity higher than the coal, but lower than the impurities. The pieces have a diameter larger than the openings in the screen. The coal is fed in the same manner and works its way across the screen to the sill where it overflows with the water into the sluiceway in front. The refuse works its way through the layer of feldspar into the hopped bottom of the jig box from where it passes through the refuse gate into a sluiceway by gravity and is carried to the refuse settling tank. These jigs can be placed in a battery up to twelve, so that one shaft and sluiceway will serve the entire battery. In the operation of these jigs it is very important that the coal treated in each jig be of uniform size.

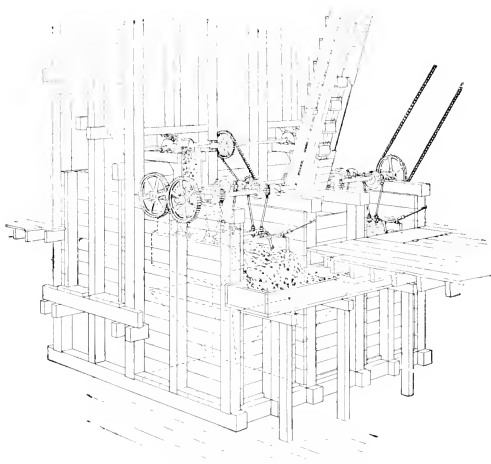
The Hartz jig is about the same as the above in general operation. It differs in construction, being made of sheet steel with semi-circular bottom.

Berard's machine is another of similar operation. This machine was introduced as early as 1851 in London. It was used in Pennsylvania for a few years ^{about} ~~in~~ 1873.

The Stutz jig has a few special appliances, the bottom



THE STEWART TYPE OF JIG



THE STEWART TYPE OF JIG

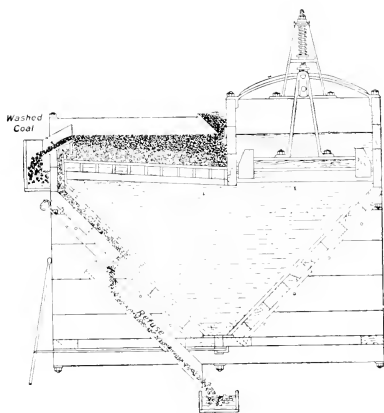
GENERAL VIEW SHOWING RAW COAL FEED, WASHED COAL SLUICE, AND EFFLUENT TRAY

being of special shape. In the improved machine the pulsating mechanism is placed directly under the screen on which the coal rests. A plant with this machinery capable of handling 600 tons per day of 10 hours has been estimated to cost \$16000.00. The cost of washing has been given as 2 cents per ton, but this does not include interest and depreciation.

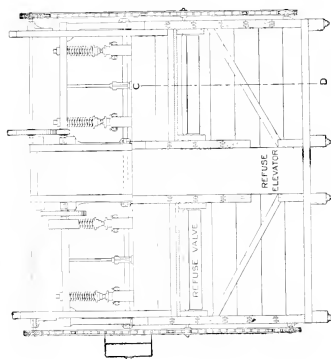
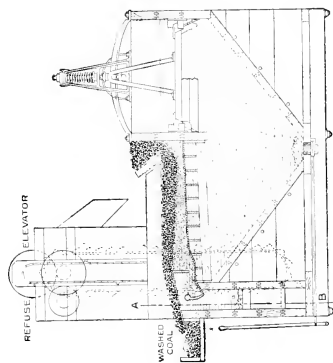
The Stein jig has a special method of arrangement and handling the coal. The jigs, which resemble the others, are double. Coal is fed at the side of one jig. It passes over this bed to the next jig from which it is discharged into a sluiceway. There is thus obtained a long path and a thorough separation is accomplished. One result gives a reduction from 35% to 10% ash and 3% to 1.35% sulphur.

The Stewart jig operates a little differently than the others. This jig consists of a box with a perforated bottom which is suspended in a tank of water from eccentric rods by means of which it is given the pulsating motion. The bottom is inclined. The coal is fed at the upper end and works its way across the screen where it is washed over the sill with the water. The refuse passes through a valve in the front of the jig into the hoppers bottom of the jig from which it is discharged by an elevator. The coal that is fed to the jig is not sized. The capacity of each jig is higher than that of the Lührig jigs, but with small size coal the operation is not as economical.

The Diescher washer is similar to the Stewart. The



"NEW CENTURY" NUT COAL JIG



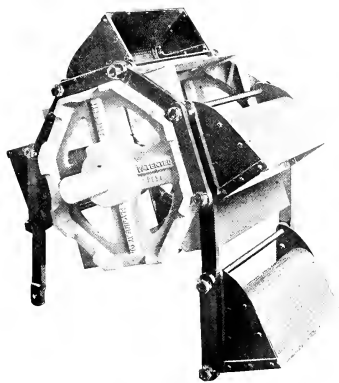
"NEW CENTURY" DIFFERENTIAL MOTION JIG
AS EMPLOYED IN THE WASHING OF FIRE COAL

jig has a different shaped bed and has some variations in the mechanical construction.

The special feature of the New Century jig is the plunger. By means of a spring a quick stroke is accomplished which seems to be very effective in separating fine coals.

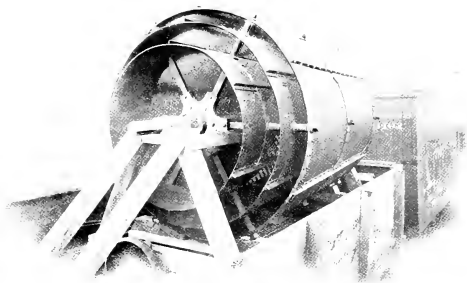
Luhrig, New Century, and Stewart type jigs are commonly used in the Illinois coal fields. In the selection of jigs for this plant the Luhrig type were selected because of the economical construction, operation and high efficiency. The entire plant, in fact, has been equipped with Luhrig apparatus.

The elevators with the exception of the raw coal, are Luhrig type. A cut here given shows the type of bucket and method of discharge. The buckets are perforated to allow as much water as possible to drain off before the coal is placed in the storage bin. This moisture remaining in the coal is a serious problem, and will be mentioned later. The head wheels are cast iron. The elevator is driven from the head-end by means of a chain-drive from a jack shaft. The speed reduction is accomplished by reducing from the jack shaft to a counter shaft and again by means of a spur and pinion from the counter to the head shaft. The head and counter shaft are supported on a Luhrig take-up which facilitates the fitting of the chain when construction or repairing. This take-up consists of a sole plate on which the bearings rest. They are spaced



LÜHRIG ELEVATOR

SHOWING BUCKETS DISCHARGING OVER HEAD WHEEL



ONE OF THE SEVERAL TYPES OF SCREENS EMPLOYED FOR SIZING COAL BEFORE WASHING, WHEN MORE THAN TWO OPERATIONS ARE REQUIRED.

to accommodate the gears and are held thus by a spacing rod. By means of a take-up screw both bearings are moved at the same time, thus allowing adjustment of the head wheel without disturbing the gears.

The raw coal screen is shown by the sketch. It forms a compact and efficient method of grading the coal. Shaking screens are sometimes used, but they require more room and seem to have no greater advantages, although claimed by some to have. The screens are driven by means of gears and pinions. The jackets are supported by spider arms. The rinsing and resizing screens are all single jacketed.

An important feature in coal washing is to have coal of uniform size fed to each jig. This is especially true of fine coal. The separation of the different sizes is nicely accomplished in the hydraulic grading box. This consists of a long box with hompered divisions across the bottom. The coal is sluiced into the box at one end, the larger sizes being heaviest settle in the first compartment and are sluiced to the first jig. The next size collects in the next compartment, and so on through the six grades. In this manner each jig can be regulated to a nicety to wash its product, and excellent results are obtained.

An important feature of the Luhrig system is the recovery of the sludge. In the older style washers the water used in the jigs was allowed to run off carrying with it much fine coal in the form of dust. Mr. Karl Luhrig saved this by allowing the water with the fine coal to pass into a large settling tank, known as the sludge tank.

The fine coal is here allowed to settle. A slowly moving conveyor then carries it to an elevator pit located at one end of the tank.

At the end opposite to that at which the elevator is located is the suction pipe for the centrifugal circulating pump. The water at this end is clear enough to allow its use in the jigs. The water is thus used over and over again. The only water that is lost is that which is used in sluicing away the refuse. Enough fresh water is added as rinsing water to counteract this loss and keep the quantity constant.

The Plant
Design. In the design of this plant the following conditions are to be met. 500 tons of raw coal are to be washed in 8 hours, washing the product from the mine that passes through a 3" round perforation producing 5 sizes of washed coal as follows:

Size	Percent	Thro'	Over
#1 Nut	20	3"	1 3/4"
#2 "	23	1 5/4	1"
#3 "	9	1"	3/4"
#4 Fine	33	3/4"	1/4"
#5 "	15	1/4"	-

Sized according to Illinois Coal Operators' Association standard. All perforations in screens to be round.

It is assumed that the mine will produce from 800 to 100 tons of raw coal per day, and that 50% will pass through the 3" perforations.

The following is an analysis of the coal which is from the Illinois coal field and is taken as a basis for the design of the plant.

In the raw coal there is 25% ash, that is, in the coal passing through the 3" perforations. The coal analysed in specific gravity solution gives the following results:

Raw coal		#1 Sink
61% Floats	73.8% F.	24% F.
7% Ash	9% A.	19% A.
<hr/>		
39% Sink	26.25% S.	76% S.
50% Ash	66% A.	66% A.
<hr/>		
#1	#2	
1.35 sol.	1.45 sol.	1.45

Or 12.8% raw coal lies between 1.35 and 1.45, and carries 19% ash.

OPERATION AND OUTLINE OF PLANT.

The coal will be taken from the mine tippie where it will pass through a 3" round perforated screen and be carried to the raw coal bin by an inclined flight conveyor which will be operated independent of the washery machinery to allow the bin to be filled in case the washery is shut down.

From the raw coal bin coal will be fed to a continuous bucket conveyor by means of a Link Belt revolving feeder which will put a uniform load on the elevators and keep a uniform amount fed to the jigs. The coal will be lifted by this elevator to a triple jacketed revolving sizing screen which will separate #1, 2, and 3, which will pass to their respective jigs while 4 and 5 will pass through

into the hydraulic grading box.

Each size of coal will be washed separately, two jigs being provided for #1, three for #2, two for #3, and six for #4 and 5.

After passing through their respective jigs #1, 2, and 3 washed coal will be sluiced to draining screens located directly over bins for their storage. These draining screens will also act as resizing screens so that any coal that has been broken and is undersize will be separated here and pass with the water to a redraining screen where sizes over #4 will be separated and returned to the boot of the raw coal elevator. It will thus be allowed to take its proper place in the rewashing. The fine coal and water passing through the redraining screen will pass into the hydraulic grading box. From the grading box the uniform sizes will pass into the fine coal jigs, six in number, and be washed separately. The washed coal will pass over the sill of the jig and be sluiced to a large revolving screen. #4 will pass over ^{the screen} into a sluiceway leading to the boot of the Lührig elevator which will carry it to the top and empty it into the bin. #5 which consists of much dust and fine particles will pass through ^{the screen} with the water into the sludge recovery tank located directly beneath the screen. As the fine coal settles it will be carried to the elevator pit by a flight conveyor. A Lührig elevator will lift the coal to the #5 bin.

The nut coal will be rinsed by a spray of water on the draining screens; #4 by a spray on the separating screen, and #5 by a spray on the coal as it is being lifted to the bin from the sludge tank.

The refuse passing through the slate valves of the nut coal jigs will be carried by a screw conveyor to the boot of a Luhrig elevator which will lift the slate to a sluiceway and by which it will be sluiced to the refuse heap. The impurities from the fine coal jigs will pass to a settling tank from which it will be elevated by a Luhrig elevator to the refuse sluiceway.

The nut coal jigs will be connected with the refuse settling tank so that the fine particles passing with the impurities through the screen and settling in the bottom of the jigs can be run off when necessary.

The water for the nut coal jigs will be taken from the end of the sludge tank opposite to that at which the elevator is located. It will be lifted by a centrifugal pump to the jigs. The pump will be belted to a pulley on the engine crank shaft.

Fresh water for rinsing the coal will be supplied from an outside source and will be supplied to the screens by a steam pump.

The sludge and settling tanks will be provided with large size drain pipes so that the water could be run out in case of a shut-down in winter.

The building will be heated by steam. The various gates and valves will be provided with steam connections

to prevent their freezing in winter.

The building will be lighted with electricity to allow night work. The raw coal storage bins will have a capacity of 200 tons, and the washed coal storage bins a capacity of 270 tons.

SPECIFICATIONS.

Revolving feeder and gate for raw coal bin.

1 Link-Belt revolving feeder, complete.

Also 1 "Spellman" gate complete with levers, etc. for delivery of raw coal from bin to raw coal elevator.

Raw Coal Elevator.

One continuous bucket elevator 60 ft. centers for lifting coal from raw coal bin to raw coal sizing screen. This elevator is to be made up of 16" x 12" x 18" #10 steel continuous buckets, carried by double strand of 18" pitch bar link rolling chain, complete with necessary head, counter, and foot shafts, bearings, collars, sprocket wheels, patent spur equalizing gears, driving pulley on countershaft, and sprocket wheel on foot shaft for driving revolving feeder, also flat steel track for chain.

Raw Coal Screen.

One triple jacketed revolving screen for raw coal, inner jacket 12 ft. long; middle jacket 11 ft. long, and outer jacket 10 ft. long, complete, with 5 15/16" rough turned screen shaft, spiders, rings, steel cone, and covering of 1/4" plate with 3/4" round perforations, and

1" round perforations for outer and middle jacket, respectively, and of 3/8" plate with 1 3/4" round perforations for the inner jacket, also bearing and countershaft with bevel gear drive.

Nut Coal Jigs.

Seven Lührig nut coal jigs, complete with shafts, eccentrics, etc. These jigs to be in one battery.

Refuse Elevator from Nut Coal Jigs.

One #5 Lührig elevator, 15 ft. centers, complete, with all necessary head, and foot mechanism, chain and buckets, angle guides, back lining, and driving countershaft with fittings.

Nut Coal Draining Screens.

Five 3ft. diameter x 6ft. long nut coal draining screens, complete, with bearings, spiders, and coverings of #10 plate - two to have 1 3/4" perforations, two to have 1" perforations, and one to have 3/4" perforations.

Also one 3'0" x 6'0" screen with covering of #10 plate and 3/4" perforations for over size coal in redraining. These screens to be complete with counter shaft, etc.

Fine Coal Jigs.

Six Lührig fine coal jigs, complete, with shafts, eccentrics, feldspar beds, etc. These jigs to be in one battery.

Fine Coal Draining Screen.

One 4'0" x 10'0" revolving screen, complete, with shaft, bearings, spiders, rings, and covering of #10 steel plate with 1/4" round perforations.

#4 Fine Coal Elevator.

One #1 Lührig elevator, 38 ft. centers, complete, with all necessary head and foot mechanism, chain and bucket angle guides, back lining, and driving countershaft with fittings.

Sludge Recovery.

One conveyor, about 46 ft. horizontal centers, and 10 ft. vertical centers, complete, with necessary head, counter and corner shafts, bearings, collars, sprocket wheels, gears, and 3 strands of #730 chain, each 122 ft. long, fitted with 3/16" steel flights, having reinforcing angles and wearing shoes; also necessary steel tracking.

#5 Coal Elevator.

One #4 Lührig elevator, 55 ft. centers, complete, with head and foot mechanism, chain and buckets, angle guides, back lining, and driving countershaft with fittings.

Fine Coal Refuse Elevator.

One #4 Lührig elevator, 43 ft. centers, complete, with head and foot mechanism, chain and buckets, angle guides, back lining, and driving countershaft with fittings.

Gates for Washed Coal Bins.

Five Link-Belt steam-jacketed gates, complete.

Bin and Sluice Lining.

Necessary #12 steel plate linings for bottoms of raw and washed coal bins; #12 steel lining for chutes, and #14 steel lining for sluiceways.

Pumps.

One #8 Morris Imperial standard double suction

horizontal pump, complete, with pulley. for circulating water for jigs.

One #25 - 7" x 5" x 10" "Gardner" low service duplex steam pump for fresh water.

Piping.

Necessary piping, with valves and fittings, from sludge recovery to pump, and to jigs, grading box and refuse sluice.

Necessary piping from fresh water pump to sludge recovery, draining screens, and to refuse sluice.

Steam piping to steam gates from steam line in engine room. Also steam piping to steam coils for heating building.

Necessary 12" vitrified sewer pipe for draining sludge and refuse pits.

Engine, Line Shaft, etc.

One 13" x 18" double class "A" H. S. & G. #122 horizontal engine, 160 R.P.M., 130 H.P., with 80 lbs. steam pressure, complete, with usual fittings, and a 90" 4-groove split flywheel, sheave for 1 3/8" manila rope, also pulley for driving centrifugal pump.

Necessary line shafting, jack shafting and counter-shafting, with rope transmission to main shaft, rubber belt to jack shafts and chain connection to the various appurtenances, elevators, conveyors, screens, etc.

Building.

The lumber used for the building will be #1 common yellow pine, and for tanks lumber of suitable quality. All lumber to be surfaced four sides. The building, with the exception of the bins, and sludge tank, will be covered with drop siding and complete with corner boards, window casing, frieze, etc. The roofing will be 2-ply composition, and necessary gutters will be provided. The building to be complete with all necessary doors, windows, and stairways, the windows being glazed. All exposed wood work is to be painted.

With the building are to be provided all necessary timber supports for machinery, and all necessary tanks, chutes, sluiceways, elevator casings, etc.

Foundations are to be concrete.

Many coals of poor quality in the raw state are made excellent fuel coals by washing, others of low quality and value are relatively increased. The substances that go to make up the ash in the furnace are removed by washing. It is thus that the quality is increased. As coal is now bought to a large extent on the heat unit basis it behooves the coal operators to have as small a percent of ash as possible.

By the removal of the impurities which to a large extent form the clinker in the furnace, such as pyrites and clay, the capacity of the furnace is often increased.

Another advantage of washed coal is that it is of uniform size when delivered, which is also conducive toward an increased furnace capacity by giving a uniform fire bed.

In the manufacture of coke the treatment of the coal is an important matter. Coal of excellent coking qualities, but which contains too much ash or an excess of sulphur can often be improved by washing to make a very high-class coke. In the design of this plant the coal has been treated only with reference to boiler fuel.

One disadvantage encountered in the treatment of coal is the amount of water that is retained by the coal, especially by the #5 size. It is very difficult to lower the percent of water which is often as high as 10%; where the coal has plenty a chance to drain, as in being transported quite a distance, the coal drains quite thoroughly in the large sizes. The percentage of water above given includes the water that is contained in the pores of the coal as it comes from the mine. Often this runs as high as 8%. The water added from washing remains on the outside and drains off quite readily in the large sizes, but the #5 size contains so much fine stuff that it packs very close and holds the moisture. Attempts have been made to reduce the moisture but have as yet been unsuccessful in most cases, the treatment being too expensive.

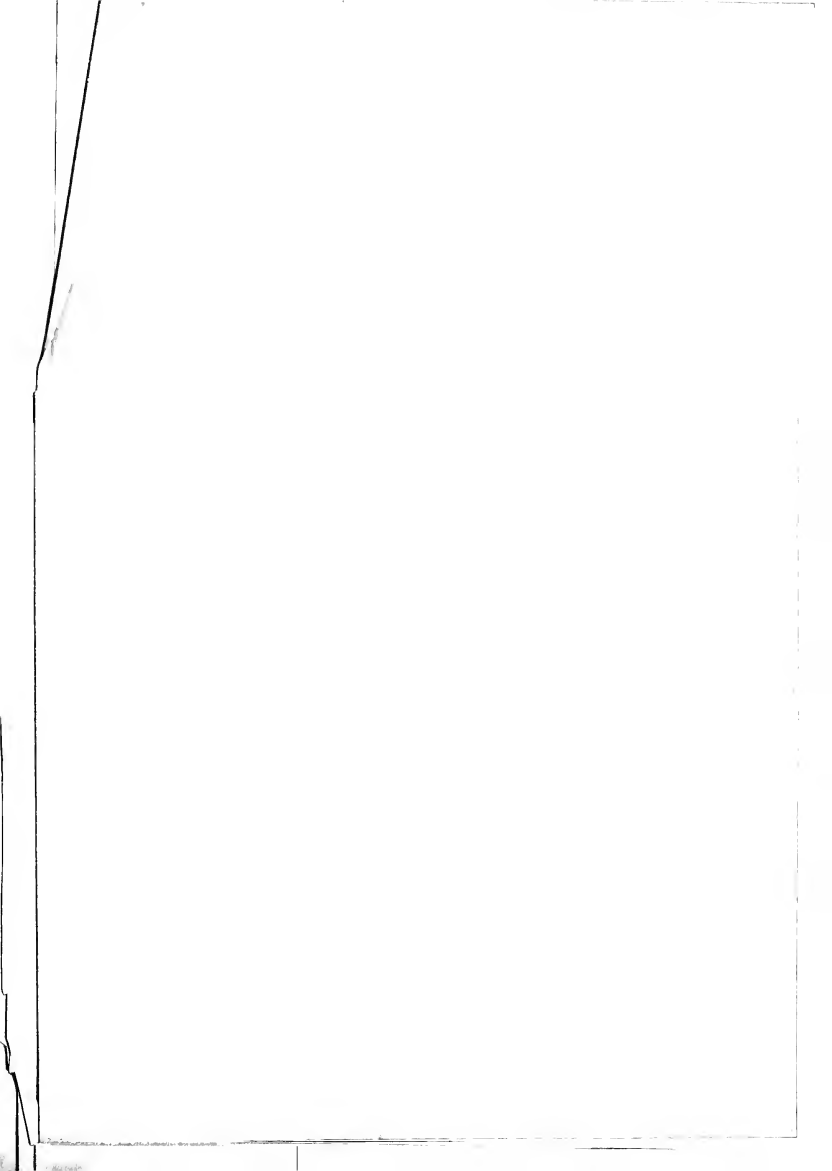
In the preparation of this paper much valuable information has been obtained from Mr. A. J. Sayers, of the Link-Belt Machinery Company, Chicago; John Fulton's book on Coke

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has been found to be very instructive, as well as Richards' on Ore Dressing. The plant and mine of the Consolidated Coal Company, at Collinsville, Illinois, was visited. This plant is of about the same capacity and general arrangement as the one given in this design, employing Luhrig apparatus. At East St. Louis, Illinois, the plant of the Bessemer Washed Coal Company was inspected. This plant washes coal which the operators buy from the mines in the Illinois coal fields. The mine owners^{are} often glad to get rid of the slack which can be washed and sold at a profit. This plant uses the Stewart type jig with Luhrig recovery. From the descriptions here given the importance of coal washing can be seen, as also the magnitude to which it has now developed. As the better beds of coal are used up the treatment of the poorer grades to make them fit for market be washing is bound to occur.

In preparing the design of this plant it was first attempted to have the machinery arranged to allow for expansion. As an entirely new equipment would be necessary, and also alterations in the entire plant, it was thought that it would be better to have a nearly independent plant than to try to arrange any additions. As the Stewart jigs have a larger capacity than Luhrig, and with large size coal they are quite as economical as the Luhrig, it was thought at first to install a fewer number of nut coal jigs by using the Stewart type. It was found, however, that this had been tried, but had not been particularly successful, so this



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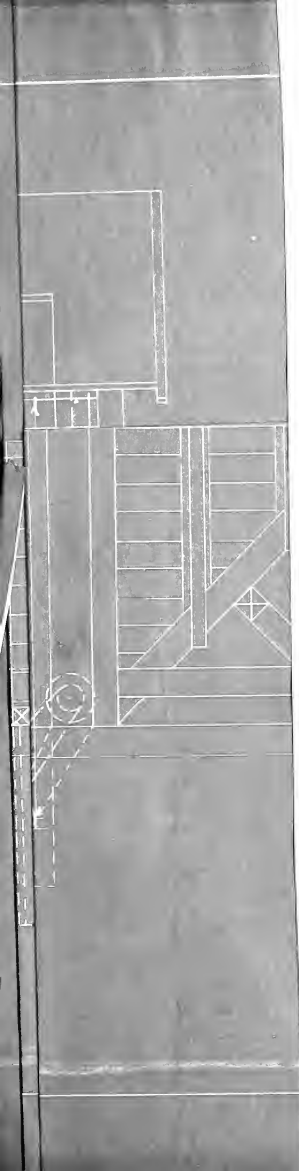
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was dropped and the entire plant equipped with Lührig apparatus. The plant of the Consolidated Coal Company has been operating for about a year, running sixteen hours per day, and is giving excellent satisfaction. No results are obtainable as to the efficiency of the plant as yet, but the fact that it was installed by the Link-Belt Machinery Company will insure a high mark.

Calculations.

In the design of this plant the speed of the screen and elevators, and sizes of jigs, tanks, etc, were determined as far as possible from results found to be satisfactory in practice.

Raw Coal Elevator.

This elevator will be required to lift about 60 tons of coal per hour, or 1 ton per minute. Each bucket will hold about 40 lbs.

$$\frac{2000}{40} = 50 \text{ buckets per minute.}$$

Each bucket is 18" deep. $50 \times 18 = 75$ ft. per minute = speed required. Assuming this as 80% of capacity, for full capacity a speed of about 100 ft. per minute will be required.

The head wheels being 36 inches in diameter, about 11 R.P.M. will be necessary. With the arrangement of shafting as shown there are 3 reductions between the line shaft at 150 R.P.M. and the head shaft at 11 R.P.M.

With equalizing gears of 46.75" and 8" diameter the countershaft will run at 66 R.P.M. $\frac{46.75 \times 11}{8} = 66$.

With 24" and 36" sprockets on chain drive from jack shaft to countershaft the speed will be raised to 99 R.P.M.

$$\frac{36 \times 66}{24} = 99 \text{ R.P.M.}$$

With 48" and 32" pulleys from jack to line shaft the speed of 150 R.P.M. on line shaft will be met.

$$\frac{48 \times 99}{32} = 148.5$$

The belt could be counted on to slip enough to give about 11 R.P.M. at head shaft.

Raw Coal Screen.

80% of coal will pass through first screen, which equals 48 tons, allowing 4.3 sq.ft. per ton hour;

$$48 \times 4.3 = 206 \text{ sq.ft. required.}$$

Screen is 12 ft. long.

$$\frac{206}{\pi \times 12} = 5.5 \text{ ft. = diameter.}$$

57% will pass through next screen;

$$.57 \times 120000 = 68400 \text{ lbs} = 34.2 \text{ tons per hour.}$$

Allowing 6 1/2 sq.ft. per ton hour.

$$34.2 \times 6.5 = 222 \text{ sq. ft. of screen;}$$

second screen 11 ft. long. $\frac{222}{11 \times 3.14} = 6.5 \text{ ft. diameter.}$

48% will pass through third screen.

$$.48 \times 120000 = 57600 \text{ lbs.} = 28.8 \text{ tons per hour.}$$

Allowing 8.7 sq. ft. per ton hour

$$28.8 \times 8.7 = 250 \text{ sq. ft. screen.}$$

Screen is 10 ft. long. $\frac{250}{10 \times 3.14} = 8 \text{ ft. diameter.}$

With screen running at 9 R.P.M. a peripheral speed of 226 ft. per minute is reached.

To obtain 9 R.P.M. at screen three reductions are used:

$$\frac{66.52 \times 9}{11.38} = 52.5 \text{ R.P.M. speed of countershaft.}$$

66.52 and 11.38 = diameters of gear and pinion respectively.

$$\text{Belt to jack shaft. } \frac{52.5 \times 38}{20} = 100 \text{ R.P.M. speed of jack}$$

shaft - 38 and 20 = diameters of pulleys.

$$\text{Belt to line shaft: } \frac{48 \times 100}{32} = 150 \text{ R.P.M. - speed of line}$$

shaft. 48" and 32" = diameters of pulleys.

Nut Refuse Elevators.

From 100 R.P.M. on jack shaft to 6 R.P.M. of head shaft through two reductions: $\frac{24 \times 48}{100} = 11.5$ " diameter of the

$$\text{sprocket on jack shaft. } \frac{24 \times 9.55}{6} = 39.63$$

spur gear on head shaft.

Fire Coal Elevators.

Using same gears as above. Then it is necessary to reduce from 150 to 24 through two reductions.

150 on line shaft to 81 on jack shaft -

81 on jack to 24 on counter shaft.

$$\frac{24 \times 48}{81} = 14 \frac{1}{4}$$

$$\frac{150 \times 24}{81} = 45$$

" = diameter of pulley on line shaft.

Nut Coal Jigs.

75 R.P.M. of eccentric shaft from 150 on line shaft.

$\frac{150}{75}$ = ratio 2 to 1, which can be had by using 36 and 18 inch pulleys.

Fine Coal Jigs.

125 R.P.M. of eccentric from 150 R.P.M. of line shaft.

$\frac{150}{125}$ = ratio of 6 to 5, which is given by 36 and 30 inch pulleys.

Resizing Screens.

150 R.P.M. on line shaft to 22.5 through two reductions:

$\frac{150 \times 22}{48}$ = 69 R.P.M.

$\frac{69}{22.5}$ = ratio of 3 to 1 for bevel gears, which is obtained

15.28 and 5.09 inch diameters resp.

#4 and #5 Screens.

150 R.P.M. to 15.7 R.P.M. through two reductions:

$\frac{16 \times 150}{40}$ = 60 R.P.M.; 16 and 40 inch. = diameters of pulleys.

$\frac{11.75 \times 60}{45}$ = 15.7 R.P.M.; 11.75 and 45 inch. = the diameters of sprockets.

$4 \times 3.14 \times 15.7$ = 197 ft. per minute peripheral velocity of screen.

Scraper Conveyor.

60 R.P.M. of jack shaft to 4 R.P.M. of scraper shaft through two reductions.

$\frac{60 \times 11.14}{25} = 26.7$ R.P.M.; 11.14 and 25 inch. = diameters of bevel gears.

$\frac{7.24 \times 26.7}{47.9} = 4$ R.P.M.; 7.24 and 47.9 = diameters of pinion and spur gear.

Feeder

At 11 R.P.M. 66 buckets will be filled per minute.

With three divisions on feeder $66/3 = 22$ R.P.M. necessary.

Foot shaft runs at 11 R.P.M., which gives a ratio of 2 to 1.

With 30 and 15 teeth on sprockets this ratio is obtained;

sprockets are 24 $\frac{3}{4}$ " and 12 $\frac{1}{2}$ " in diameter resp.

The horse power supplied is very liberal, but as fuel is a small item it was deemed best to allow plenty of power.

The power will be used as follows:

Each jig has been allowed 1.75 H.P.

13 jigs will require $13 \times 1.75 = 22.75$ H.P.

Each small elevator has been allowed 5 H.P.

4 elevators require 20 H.P.

For the centrifugal pump 1 H.P. has been allowed for each foot lifted, which is 30.

For the raw coal elevator 10 H.P. has been allowed.

Then allowing 20 H.P. for the screens, shafting and scraper conveyor a total of 103 H.P. is reached.

The H. S. & G. Company's nearest size would be 50 H.P. which when placed double would give 100 H.P. It would be necessary to run overload with this size so the next size was selected which is 65 H.P. giving 130 H.P. when placed double. The engine is not protected by placing it in an enclosed room so that it is subjected to quite rough treatment; thus an excess of power at the start is not unreasonable.

